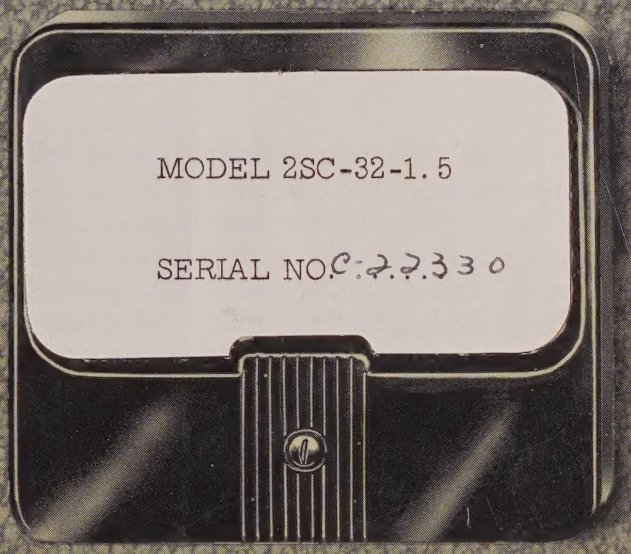
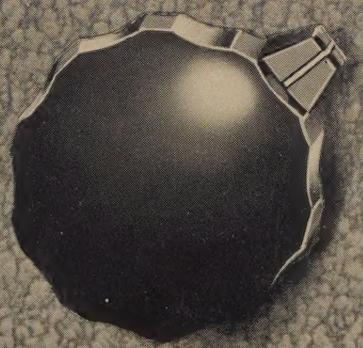
Kepco

INSTRUCTION MANUAL



✳ VOLTAGE REGULATED POWER SUPPLIES



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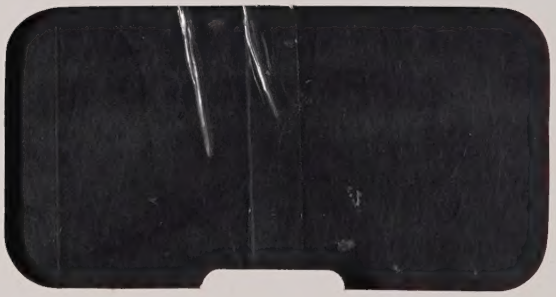

MODEL 2SC-32-1.5

SERIAL NO. C-2.2.330

KEPCO, INC.
131 - 38 Sanford Avenue
Flushing 55, New York

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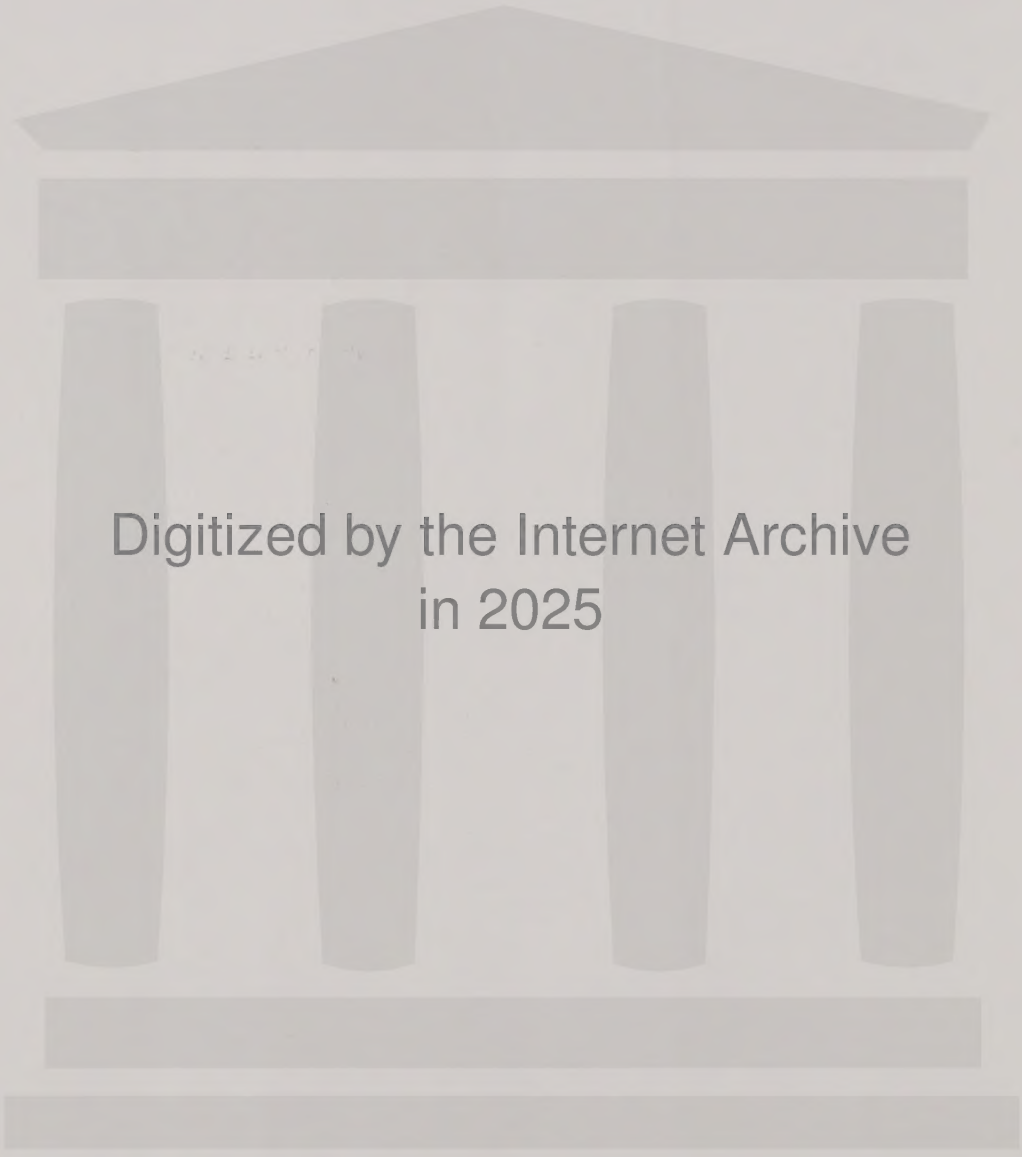
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Parts Lists

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Schematic Diagrams of Power and Control Units

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SECTION A

SPECIFICATIONS AND CONTROLS

I. ELECTRICAL AND PHYSICAL SPECIFICATIONS:

Each output of this dual unit conforms to the following specifications:

.....DC OUTPUT VOLTAGE:

0-32 volts DC, continuously variable.

.....DC OUTPUT CURRENT:

0-1.5 amperes, continuous duty.

.....AC INPUT:

105-125 volts AC, 50-65 CPS, 2.7 amperes maximum.

.....REGULATION:

Line: Less than 0.01% for line change 105-125 volts AC at any output voltage in the specified range.

Load: Less than 0.01% or 0.002 volt, whichever is greater, for load change 0 to maximum, at any output voltage in the specified range.

.....RIPPLE:

0.001 volt RMS.

.....STABILITY:

Output voltage variation less than 0.01% or 0.002 volt, whichever is greater, over a period of 8 hours after unit has reached equilibrium. Approximately 3/4 of an hour is required for this unit to reach equilibrium from a "cold start".

.....OUTPUT IMPEDANCE:

Less than 0.01 ohm from DC to 1 KC.

Less than 0.1 ohm from 1 KC to 100 KC.

... ...RECOVERY TIME:

50 microseconds.

.....TEMPERATURE COEFFICIENT:

Output voltage changes less than 0.01% per °C.

..... .AMBIENT OPERATING TEMPERATURE:

50°C maximum. A pre-set protective circuit turns off unit whenever over-temperature condition occurs. Unit is reset by interrupting input.

.....STORAGE TEMPERATURE:

40°C to + 85°C.

.....DIMENSIONS:

Height 7", width 19", depth 13".

.....COLOR:

Kepco standard gray hammertone.

.....METERS: (for each output)

Voltmeter: 0-50 volts, 2-1/2" wide view.

Ammeter: 0-1.5 amperes, 2-1/2" wide view.

II. TERMINALS AND CONTROLS:

(On Front Panel):

1. DC OUTPUT and ground terminals marked and isolated from chassis.

   Either positive or negative terminal may be grounded.

2. 10 turn voltage control, 0.005% resolution.

3. AC input power ON-OFF switch.

(On Rear of Unit):

1. DC OUTPUT and ground terminals.

2. Two remote ERROR SENSING terminals on rear terminal board enable regulation to be maintained directly at the load by providing a means of compensating for voltage drops across the load supply leads. (See Diagram and Procedure on Page C-1).

3. Two remote OUTPUT VOLTAGE CONTROL terminals on rear terminal board enable output voltage to be controlled remotely at approximately 300 ohms/volt (i.e. for each 300 ohms change in a remote control resistance, the output voltage changes by approximately one volt).

   (See Diagram and Procedure on Page C-2).

4. CURRENT LIMIT ADJUST (CL) screwdriver adjustment on the Control Unit (TRAM) provides a means of setting the current limit at any value in the range from 0 to 120% of rated full load current. As a safety feature, this unit has been designed to automatically limit at 120% of rated full load current so that the wattage dissipation of the series pass transistors is never exceeded.

NOTE: As the current limit is approached, regulation deteriorates slightly. Consequently, for best regulation throughout the operating load current range, the Current Limit Adjust should be set about 25% higher than the desired maximum output current.

ADDITIONAL FEATURES:

5. Maximum Current Adjust: The screwdriver adjustment on the Control Unit is factory set at the maximum safe current limit for the unit. THIS SETTING SHOULD NOT BE CHANGED UNLESS FULL RATED LOAD CURRENT CANNOT BE OBTAINED WHEN THE POWER SUPPLY IS CONNECTED FOR REMOTE ERROR SENSING WITH LONG SENSING LEADS. In this special case, the current supplied to the load will be limited to less than 120% by the amount of voltage drop in the sensing leads unless the following steps are taken:

a) Load the supply with a remotely connected resistor which will draw slightly more than 120% of the rated supply current.

b) Turn the Current Limit Adjust to maximum clockwise.

c) Turn Maximum Current Adjust clockwise until the current is exactly 120% of rated supply current.

d) Turn Current Limit Adjust counter-clockwise to limit at desired current value.

6. Constant Current Operation: Without internal modification.

(See Diagram and Procedure on Page C-3.)

7. THE DUAL OUTPUTS OF THIS UNIT MAY BE CONNECTED IN SERIES, BUT NOT IN PARALLEL.

THE OUTPUTS ARE ISOLATED FROM EACH OTHER.

SECTION B.

THEORY OF OPERATION

This power supply is of a servo or closedloop design in which the pass elements are in series with the load. (See block diagram B-1).

The voltage drops in the closed loop system are automatically adjusted according to the comparison of a sample output voltage with the reference voltage in the CONTROL UNIT. The differential product of this comparison is amplified and fed back as the ERROR INPUT to control the voltage drop across the pass transistors. The ERROR INPUT to the PASS CIRCUITRY is a negative or degenerative feedback signal. Consequently, the voltage drop across the pass transistors is such as to oppose output voltage change.

CAPITALIZED TERMS ADOPTED FOR FOLLOWING OUTLINE AND DISCUSSION REFER TO DESIGNATIONS ON THE CIRCUIT SCHEMATICS IN THE REFERENCE INDEX.

.....I. POWER UNIT (Circuit Schematic Tile)

A. INPUT CONTROL CIRCUITRY - Controls power input from the line to the DC SOURCES.

B. DC SOURCES - Provide main and auxiliary rectified power for all DC circuitry.

C. PASS CIRCUITRY - In the MAIN DC path to the output. All current drawn by the load goes through the pass elements, hence the name.

.....II. CONTROL UNIT (Circuit Schematic Tile)

A. REFERENCE VOLTAGE CIRCUITRY - Maintains a stable voltage standard for the comparison circuitry.

B. THE COMPARISON AMPLIFIER - Functions as the "error sensing" and cascade amplification circuit.

.....III. COMPARISON BRIDGE

Consists of elements in both the POWER UNIT and CONTROL UNIT in a circuit configuration which effects a comparison between an output voltage sample and a stable reference voltage.

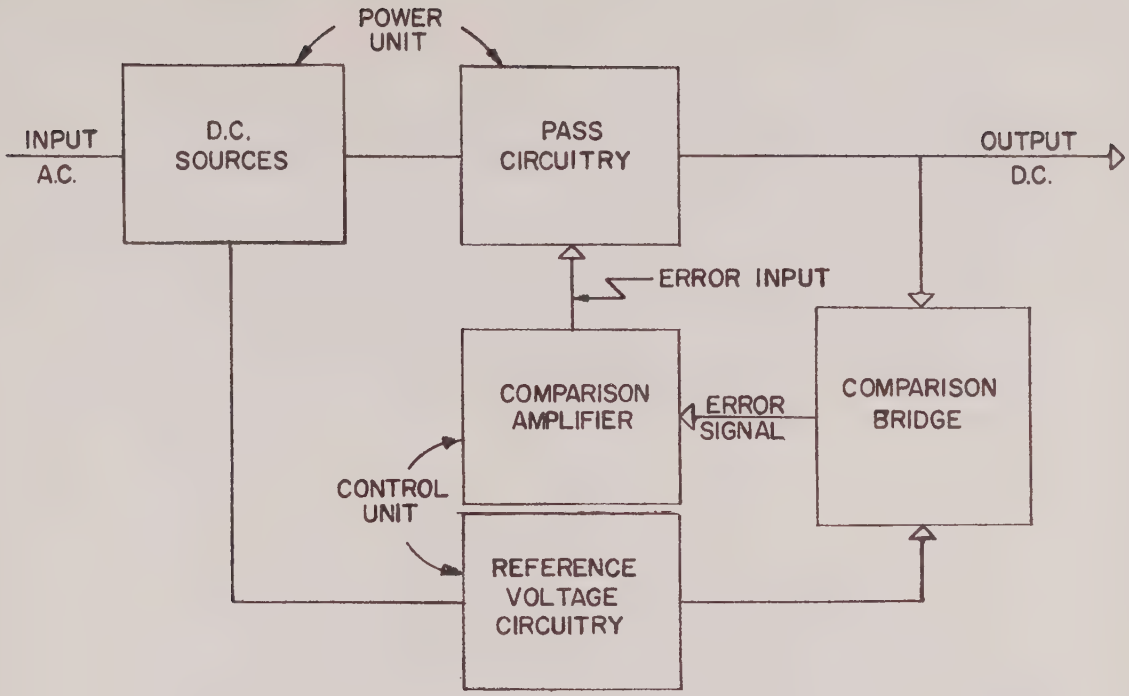


DIAGRAM B-1

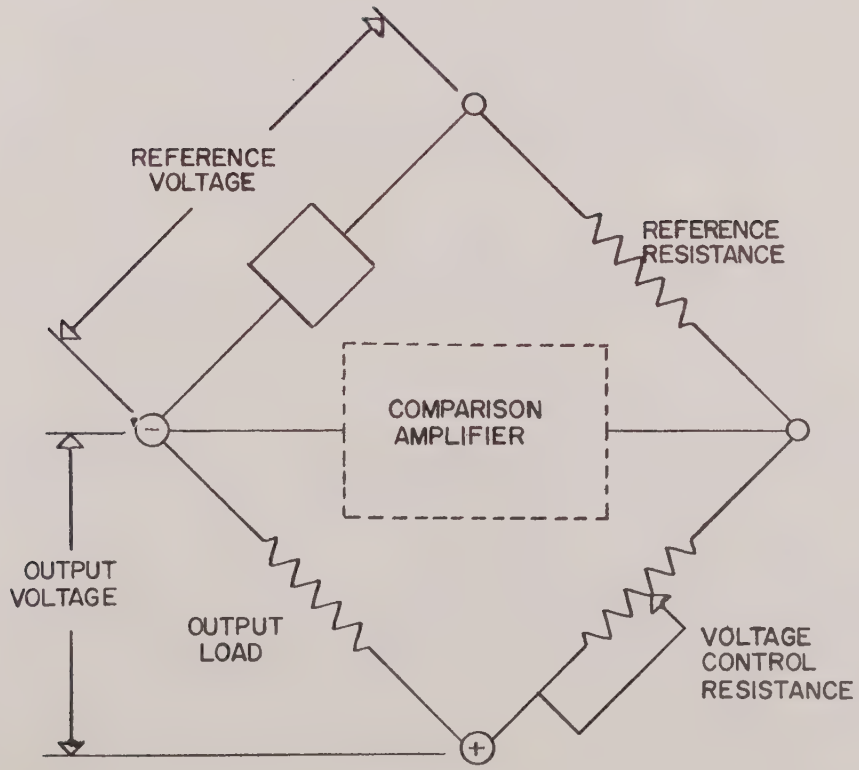


DIAGRAM B-2

NOTE:

The following discussion describes the elements of the foregoing outline in greater detail. As before, capitalized terms refer to designations on the schematic diagrams. Some of this discussion is of a general nature and may not apply in every detail to this specific model. Variations in the basic outline occur primarily in connection with the PASS CIRCUITRY INPUT CONTROL CIRCUITRY or the REFERENCE VOLTAGE CIRCUITRY and reflect design considerations relevant to the particular output requirements of the model. It should not be assumed that a set of circuit schematics is incomplete because it does not include all of the reference nomenclature used in this discussion.

.....I. POWER UNIT

A. INPUT CONTROL CIRCUIT:

(1) INPUT RELAY automatically interrupts the power input to the DC SOURCES whenever the thermostat control detects overheating in the PASS CIRCUITRY. When it is thrown in response to an over-temperature condition, it provides a discharge path for the MAIN FILTER capacitor.

(2) OVERVOLTAGE RELAY provides a discharge path for the MAIN FILTER capacitor whenever the line input is interrupted.

(3) DISCHARGE RESISTOR - When the input to the DC SOURCES is opened by interrupted line power or the action of the thermostat control, the DISCHARGE RESISTOR effectively shorts the MAIN FILTER capacitor. This prevents overvoltage surges.

B. DC SOURCES:

(1) RETURN SUPPLY (full wave rectified and filtered) - provides a return path for leakage current (I_{CO}) from the pass transistors.

It is also a bleed path which provides a minimum operating current for the emitters of the pass transistors, enabling them to continue to remain operative or "sensitive" to the ERROR INPUT when the load current becomes zero or vanishingly small.

(2) MAIN SUPPLY (full wave rectified and filtered) - Provides MAIN DC for the output, subject to the regulatory action of the PASS CIRCUITRY. The MAIN DC path includes the pass elements and the load in series.

(3) I_{co} SUPPLY (full wave rectified)- Provides a supply of current to prevent spurious biasing of the pass transistors by collector leakage current (I_{co}). I_{co} generated as a function of temperature and flowing oppositely to the emitter base current tends to alter the ERROR INPUT unless this compensating supply provides bias stabilization.

(4) COLLECTOR SUPPLIES (negative half-cycle rectified) - provide proper collector bias for the PRE-DRIVERS.

C. PASS CIRCUITRY:

The power transistors which function as pass elements may be regarded as electronic variable resistors (or variable conductors) controlled or "varied" by an amplified ERROR INPUT. The amount of current "passed" by these transistors is a function of the magnitude of the forward conducting emitter-base bias. Since the ERROR INPUT is applied to the base terminal, a negative input will aid the forward conducting bias of a PNP transistor while a positive input will reduce the forward conducting bias. In response to the polarity and magnitude of the ERROR INPUT, the pass transistors control the current and voltage distribution in the MAIN DC loop and effect a constant output voltage.

Two main classifications of pass transistors may be indicated on the schematic according to the way in which they are driven:

(1) DRIVEN PASS - "driven" by the ERROR INPUT from the CONTROL UNIT. A DRIVER and a PRE-DRIVER may be connected in cascade with the DRIVEN PASS. These amplification stages increase the response and sensitivity of the system to output voltage changes. The DRIVEN PASS may be a single series pass transistor or a series pass group of transistors connected in parallel for increased current capacity.

(2) SLAVE PASS - found in transistorized units requiring more than one series pass group in the MAIN DC path. These pass transistors "slavishly" follow the response of the DRIVEN PASS to the ERROR INPUT. The SLAVE PASSES are driven through a SLAVE VOLTAGE DIVIDER which effects an approximately equal voltage division among the series pass groups in models where the voltage range requires more than one group of series pass elements. The SLAVE PASSES may or may not have preliminary amplification stages in cascade.

When series pass groups contain transistors connected in parallel, an EQUALIZING RESISTOR is associated with each transistor. These EQUALIZING RESISTORS, tied to each emitter, provide a means of compensation for intrinsic differences among transistors within a pass group.

The expression "drop voltage" is sometimes used to describe the amount of voltage drop required of the pass elements to bring the COMPARISON BRIDGE into balance. This is the difference between the input and the desired output. True balance or stability is inherently impossible in a servo system, but the unbalance may be reduced to as small a magnitude as desired in a dynamically corrective system.

.....II. CONTROL UNIT

A. REFERENCE VOLTAGE CIRCUITRY:

The function of the REFERENCE VOLTAGE CIRCUITRY is to maintain a precise, stable voltage for the COMPARISON BRIDGE. This is normally achieved according to the model CONTROL UNIT with either of two basic design approaches:

(1) A CASCADE ZENER REFERENCE, consisting of Zener diodes of successively decreasing values in cascaded stages each of which produce an increasingly regulated reference voltage. In practice, usually only two stages are used so that in effect the first Zener diode is a regulator for a voltage reference diode.

(2) Balanced amplifier regulation - Any disparity between the bases of the transistors in the set of 1st BALANCED AMPLIFIERS is coupled to the set of 2nd BALANCED AMPLIFIERS. The 2nd BALANCED AMPLIFIERS couple this amplified "error signal" to a REFERENCE DRIVER and a REFERENCE PASS which regulate the current through a REFERENCE DIODE in a manner analogous to the action of the PASS CIRCUITRY in the POWER UNIT.

B. COMPARISON AMPLIFIER CIRCUITRY:

(1) The COMPARISON AMPLIFIER consists of a series of cascaded transistor amplifiers which boost the "error input" to a sufficient level to drive the PASS CIRCUITRY in the POWER UNIT.

(2) The COMPARISON AMPLIFIER is connected across the COMPARISON BRIDGE from the junction of the VOLTAGE CONTROL and the REFERENCE RESISTANCE to the junction of the Zener reference diode and the negative output terminal. (See Diagram B-2). This arrangement is similar to that of the null galvanometer

across a Wheatstone bridge. The unbalance in the COMPARISON BRIDGE is detected and amplified by the COMPARISON AMPLIFIER CIRCUITRY beginning a chain of circuit responses which produce an ERROR INPUT signal of proper phase and magnitude to effect corrective action by the pass circuitry.

.....III. Comparison Bridge:

(1) This bridge circuit implements the comparison between the OUTPUT VOLTAGE and the REFERENCE VOLTAGE. The signal produced by the comparison drives the COMPARISON AMPLIFIER CIRCUITRY.

(2) The Comparison Bridge is represented schematically in Diagram B-2.

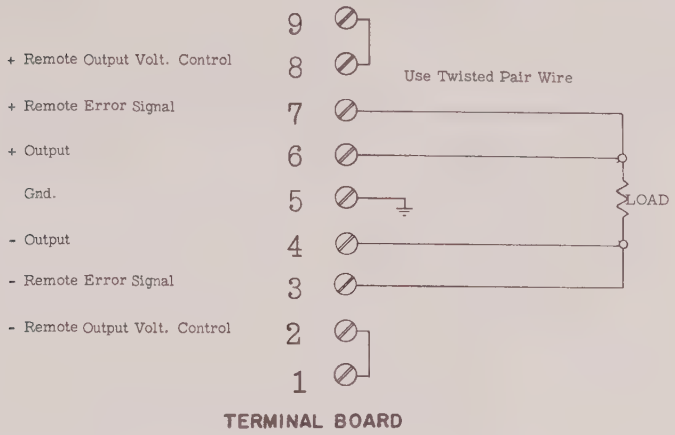
(3) Balance occurs in the Comparison Bridge when the following ratios are equal:

$$\frac{\text{Output Voltage}}{\text{Voltage Control Resistance}} = \frac{\text{Reference Voltage}}{\text{Reference Resistance}}$$

(4) When the Comparison Bridge is unbalanced by a decreasing output voltage drop across the load, it gives rise to a negative bias at the base of the COMPARISON FOLLOWER in the COMPARISON AMPLIFIER CIRCUITRY. This signal, amplified, acting as the ERROR INPUT negatively biases the base of the DRIVEN PASS, aiding its forward conducting bias and increasing the output voltage.

(5) A bridge unbalance caused by an increasing output voltage produces, of course, a chain of oppositely biased circuit responses which reduce the voltage across the load.

CONVERTING TO REMOTE ERROR SENSING



PROCEDURE:

1. With AC input disconnected, remove jumper between POSITIVE OUTPUT and POSITIVE REMOTE ERROR SIGNAL (terminals 6 and 7) between NEGATIVE OUTPUT and NEGATIVE REMOTE ERROR SIGNAL (terminals 4 and 3) on rear terminal strip.

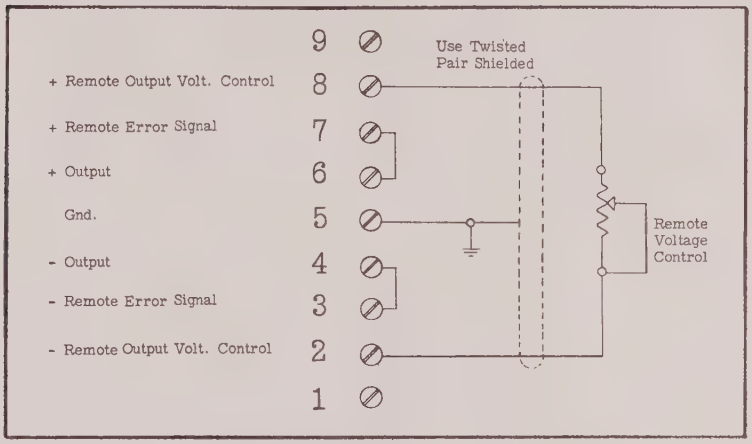
2. Using twisted pair wire, connect sensing leads from POSITIVE REMOTE ERROR SIGNAL (terminal 7) and from NEGATIVE REMOTE SIGNAL (terminal 3) to the load, observing polarities.

3. Using twisted pair wire, connect load supply leads from POSITIVE OUTPUT (terminal 6) and NEGATIVE OUTPUT (terminal 4) to the load.

NOTE: In operations requiring remote error sensing, voltage drops across the load supply leads will change the effective setting of the maximum current adjustment and possibly worsen regulation. By setting the MAXIMUM CURRENT ADJUST on the CONTROL UNIT it is possible to compensate for this effect for up to a maximum drop of 1/2 volt across the negative load supply lead. The 1/2 volt limit is imposed by the fact that this drop reduces the maximum forward conducting bias on the series pass transistors. The input base bias to the pass transistor is limited by the factory setting of the MAXIMUM CURRENT ADJUST. Consequently to avoid a deterioration in the ability of the pass transistors to follow the ERROR SIGNAL feedback and correct the output voltage, the following steps should be taken:

1. Turn CURRENT LIMIT ADJUST (if provided) to maximum clockwise position.
2. Load the power supply with the remote resistance necessary to draw slightly more than 120% of the maximum rated supply current at the indicated supply output voltage.
3. Turn MAXIMUM CURRENT ADJUST clockwise until output current reaches 120% of maximum rating.

CONVERTING TO REMOTE OUTPUT VOLTAGE CONTROL



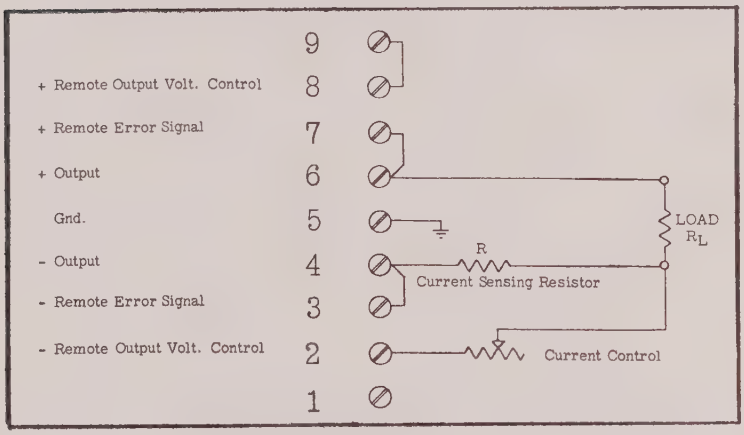
TERMINAL BOARD

PROCEDURE:

1. The REMOTE VOLTAGE CONTROL resistance, fixed or variable, should be equal to the product of the desired output voltage and the ohms per volt ratio specified for this model. (See discussion on REMOTE OUTPUT VOLTAGE CONTROL terminals in Section A).

2. With AC power disconnected, remove jumper between POSITIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 8) and terminal 9,and jumper between NEGATIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 2) and terminal 1.

3. Connect shielded twisted pair wire leads from POSITIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 8), and from NEGATIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 2) to REMOTE VOLTAGE CONTROL resistance. REMOTE VOLTAGE CONTROL, if variable, should be connected so that clockwise rotation increases resistance.



TERMINAL BOARD

PROCEDURE:

1. Remove jumper between NEGATIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 2) and terminal 1.

2. Connect a CURRENT CONTROL resistor from the NEGATIVE REMOTE OUTPUT VOLTAGE CONTROL (terminal 2) to the load as shown in the above diagram. The CURRENT CONTROL resistance should be numerically equal to (in ohms) or greater than the ohms/volt ratio specified for this unit in the discussion on REMOTE OUTPUT VOLTAGE CONTROL terminals in Section A. (e.g. for a 330 ohms/volt model use a 500 ohm pot.).

3. Choose a CURRENT SENSING resistance sufficient to produce a 1 volt drop at maximum desired output current. Connect this CURRENT SENSING resistor in series with the external load R_L and the NEGATIVE OUTPUT (terminal 4).

   Current Sensing Res. = 1 / max. output amps. desired

SECTION D

MAINTENANCE AND REPAIRS

.....GENERAL:

(1) In servicing this equipment it should be remembered that the essential regulating circuitry is a closed loop DC servo system. Careless servicing may affect the whole system. The same circuit sensitivity which enables a high degree of regulation to be obtained also increases the susceptibility of the circuit components to interrelated functional disorders when the equipment is abused. No component is an "island entire in itself". Consequently, exercise the greatest care in making repairs.

(2) Before any systematic trouble-shooting is attempted, it is advisable to establish by careful examination whether any malfunction is attributable to "simple" mechanical disorders: broken leads, loose plugs, etc. Obviously, many "simple" disorders may be symptomatic, that is, effects rather than causes of equipment malfunction.

(3) The components of this power supply have been tested and selected to provide long and trouble free operation. Under normal operating conditions, maintenance will consist merely in oiling the fan every six months. However, if component failure occurs the unit should be serviced by personnel who are thoroughly familiar with transistor circuitry. SERIOUS, COSTLY DAMAGE CAN RESULT FROM CARELESS PROBING.

(4) PARTS LOCATION: New, revised, Instruction Manuals include Parts Location Photos. These photos together with schematic diagrams should facilitate trouble-shooting and replacement.

(5) CONTROL UNITS: Control Units or "TRAMS" are of a semi-modular plug-in design. (However, it is necessary, according to the particular model, to remove bracket screws or stand-off screws before the CONTROL UNITS can be unplugged.)

.....PRECAUTIONS:

(1) CHECK ALL TRANSISTORS BEFORE REPLACING ANY. IF ASSOCIATED TRANSISTORS ARE DEFECTIVE, THE REPLACEMENT MAY BE IMMEDIATELY RUINED.

(2) IF MAJOR REPAIRS ARE NECESSARY, THE FACTORY IS PREPARED TO HANDLE THEM. UNDER NO CIRCUMSTANCES SHOULD THE UNIT BE RETURNED TO THE FACTORY WITHOUT PROPER AUTHORIZATION AND SHIPPING INSTRUCTIONS. IN ANY CORRESPONDENCE WITH THE FACTORY CONCERNING REPAIRS, THE MODEL AND SERIAL NUMBER OF THE UNIT MUST BE GIVEN TOGETHER WITH A DESCRIPTION OF THE TROUBLE ENCOUNTERED.

(3) Check all fuses before applying power after any repairs or replacements have been made.

(4) If it is found that the output voltage cannot be varied over its entire range by means of the voltage control adjustment, be careful not to short the supply as severe damage to the unit may result. In this regard, if it is detected that the output voltage does not decrease as the

voltage control is turned counter-clockwise, DO NOT CONTINUE TO TURN THE CONTROL.

(5) If it is necessary to solder transistor terminals, it is recommended that the leads be held with pliers between the transistor and the point to be soldered in order to shunt heat and reduce the possibility of damage to semi-conductor junctions. This applies as well to semi-conductor diodes.

.....CHECKING TRANSISTORS:

(1) Since a transistor is essentially a combination of semi-conductor diodes, a short in both directions between any two of its terminals is sufficient indication that the transistor is defective. Characteristically, the ratio of the forward to the reverse resistance across a transistor junction should be at least 100. In the majority of cases, the bi-directional short will occur between the collector and emitter terminals. Occasionally, a short will occur between the base and either of the other two terminals, but this condition is usually compounded with an emitter-collector short.

(2) HIGH POWER TRANSISTORS - If possible, a power transistor checker should be employed, but on a Go-No-Go basis an ohmmeter will prove adequate to detect defective components. USING THE RX1 SCALE OF THE OHMMETER, TEST FOR SHORT WITH ONE POLARITY; REVERSING POLARITIES, TEST FOR SHORT IN THE REVERSE DIRECTION. PASS TRANSISTOR groups containing elements in parallel may be checked collectively without removal from the circuit. This is done by connecting an ohmmeter directly across the collector emitter terminals

of the pass elements. If any one of the transistors in parallel is shorted, the group will, of course, be shorted and require individual checking.

NOTE: PASS TRANSISTORS are mounted in most models on the chassis in plug-in heat sinks called "STATS". In early models these STATS could be disconnected simply by pulling the STAT plug from its socket. In the newer models, for increased structural rigidity, the STATS are fastened by self-tapping hex-head screws which must be removed from the underside of the chassis.

(3) LOW POWER TRANSISTORS - Can be adequately tested using standard "packaged" transistor checkers (e.g. Baird-Atomic Beta-h_{11} Model KT-1, Barber Labs. Junction Transistor Checker Model #29). IMPORTANT: BE SURE THE PNP-NPN SELECTOR SWITCH IS IN THE CORRECT POSITION.

NOTE: Associated with each PASS TRANSISTOR connected in parallel within a pass group is a low-value resistor, called an "equalizing resistor", which operates to equalize current distribution among the pass elements. It should be ascertained whether or not a defective equalizing resistor is contributing to or has resulted from operational disorders. If one of these resistors "burns open" it effectively removes a pass transistor from the main circuit and increases the dissipation requirements of the remaining elements.

.....REGULATION:

(1) GENERAL - The regulation of this unit has been precisely measured and found to conform to specification. It must be emphasized that when the regulation specification is of a low order of magnitude great care must be exercised in proceeding to verify this measurement. Otherwise, inaccuracies may be introduced by the test. For example: a full load current drawn through an uncompensated internal resistance of 0.0002 ohm in a 32 volt-15 ampere, 0.01% regulated power supply operating at maximum voltage will produce a voltage drop equal to the % regulation specification. This amount of resistance might easily be introduced by improper setup connections for regulation measurement.

(2) DEFINITIONS -

Line Regulation is specified as the % change in output voltage as the line voltage is varied from minimum to maximum or vice versa, with the load held at a constant value.

Load Regulation is specified as the % change in output voltage as the load is varied from minimum to maximum or vice versa, with the line voltage held at a constant value.

(3) INSTRUMENTATION -

a) A differential voltmeter or Kepco Regulation Analyzer 901B can be used to measure regulation.

The output may also be monitored by a DC coupled oscilloscope provided a buck-out device is employed. The buck-out source should be of a better order of regulation than the

power supply being tested, and for maximum sensitivity the buck-out source should provide a voltage of magnitude comparable to the output setting of the supply being tested.

b) A Variac or line voltage adjuster (e.g. Kepco Model 920B) and an AC voltmeter (e.g. Weston or equivalent) can be used to control and measure the line voltage.

c) Variable Load Resistance.

(4) CONNECTIONS - A major source of inaccuracy in measuring regulation is uncompensated voltage drops due to improper connections. Regulation should be measured at the Remote Error Signal or Output Terminals on the terminal board with the load taken from either front or rear output terminals.

IT IS STRONGLY RECOMMENDED THAT CONNECTIONS FOR THE INSTRUMENTATION SET-UP FOR MEASURING REGULATION BE MADE BY LOOPING #14 BUSS AROUND the Remote Error Signal or Output terminal SCREWS ON THE TERMINAL BOARD (with jumpers in place). (See Diagram following this section.)

(5) CAUTION -

a) To prevent possible deterioration of regulation due to voltage drops across the internal buss connecting front and rear output terminals, avoid measuring regulation at the front terminals when the load is taken from the rear output.

b) When the load is remotely located with respect to the power supply or load current requirements are high, voltage drops

across output leads must be compensated for by converting to Remote Error Signal operation. (See Section C of this manual)

c) If the load is split between the front or rear output terminals, the load at the rear will receive the best regulation, the front output voltage being higher by the amount of voltage drop in the internal buss.

.....FACTORY RETURNS:

It is important that units returned to Kepco for repair be tagged with a brief description of the defects observed by the customer.

This will greatly facilitate the recording, handling and scheduling necessary to expedite servicing.

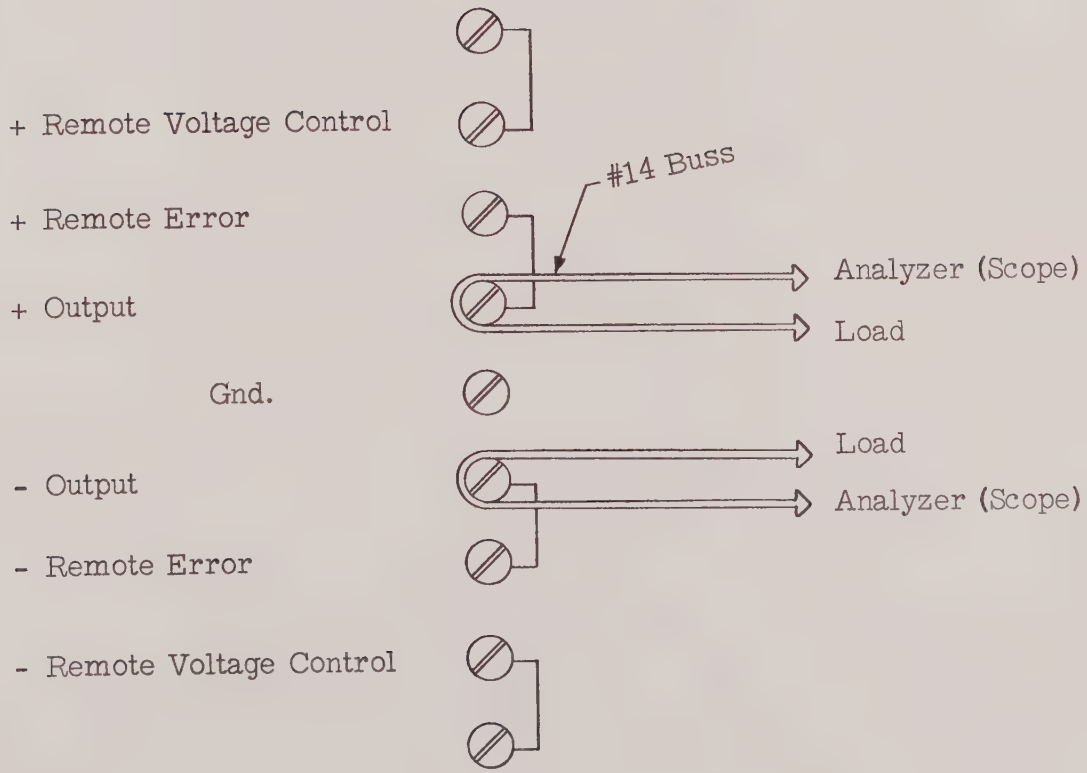
Under no circumstances should the unit be returned to the factory without proper authorization and shipping instructions. In any correspondence with the factory concerning repairs, the model and serial number of the unit must be given.

Cause numbers indicate order of probability

TROUBLE-SHOOTING CHART

SYMPTOM	CAUSE
A. NO OUTPUT	1. Overtemperature relay activated by: a. blocked ports b. ambient temperature too high c. defective fan d. defective relay 2. Input fuse blown by short in: rectifiers, transformer, main supply filter capacitor 3. Defective Control Unit (TRAM) 4. Defective ammeter
B. NO REGULATION HIGH OUTPUT VOLTAGE; VOLTAGE CONTROL DOES NOT DECREASE OUTPUT VOLTAGE (EXCEPT IN VARIAC UNITS).	1. Defective pass elements 2. Open Voltage Control Potentiometer 3. Defective Control Unit (TRAM) 4. Defective Driver or Pre-Driver associated with Pass Transistors
C. NO REGULATION LOW OUTPUT VOLTAGE	1. Current Limit Adjust set too low 2. Defective Control Unit (TRAM) 3. Incorrect conversion to remote error operation 4. Defective Main Filter capacitor

CONNECTIONS FOR REGULATION MEASUREMENT



PARTS LIST

DRAWING S-TRAM-4-01

C1	- 2	MF	200 WV
C2	- 0.4	MF	50 WV
C3	- 25	MF	25 WV
C4	- 0.1	MF	500 WV
CR1	- Germanium Diode 1N91		
Q1	- Transistor 2N441		
Q2 thru Q6	- Transistor 2N382 (Alternate 2N383)		
Q7	- Transistor 2N35 (Alternate GT-1092)		
Q8	- Transistor 2N382 (Alternate 2N383)		
Q9	- Transistor GT-1092		
Q10	- Transistor 2N35 (Alternate GT-1092)		
R1	- 3.3	K	1/2 watt
R2	- 2.2	K	1/2 watt
R3	- 500	Ohm	3 watt WW
R4	- 500	Ohm	3 watt WW
R5	- 4.7	K	1/2 watt
R6	- 2.5	K	3 watt WW
R7	- 2.5	K	3 watt WW
R8	- 10	K	3 watt WW
R9	- 2.5	K	3 watt WW
R10	- 500	Ohm	3 watt WW
R11	- 100	Ohm	3 watt WW
R12	- 100	Ohm	3 watt WW
R13	- 1.8	K	1/2 watt WW
R14	- 10	Ohm	1/2 watt
R15	- 1.5	K	1/2 watt
R16	- 1 8	K	1/2 watt
R17	- 1.5	K	1/2 watt
R18	- 220	Ohm	1/2 watt
R19	- 1.5	K	1/2 watt
R20	- 1.5	K	1/2 watt
R21	- 2.7	K	1/2 watt
R22	- 10	Ohm	1/2 watt
R23	- 100	Ohm	1 watt
R24	- 500	Ohm	2 watt Pot.
R25	- 500	Ohm	2 watt Pot.
R26	- 200	Ohm	3 watt WW
RD1	- Diode 1N429		

PARTS LIST - MODEL 2SC-32-1.5

DRAWING S-2SC-32-1.5-02

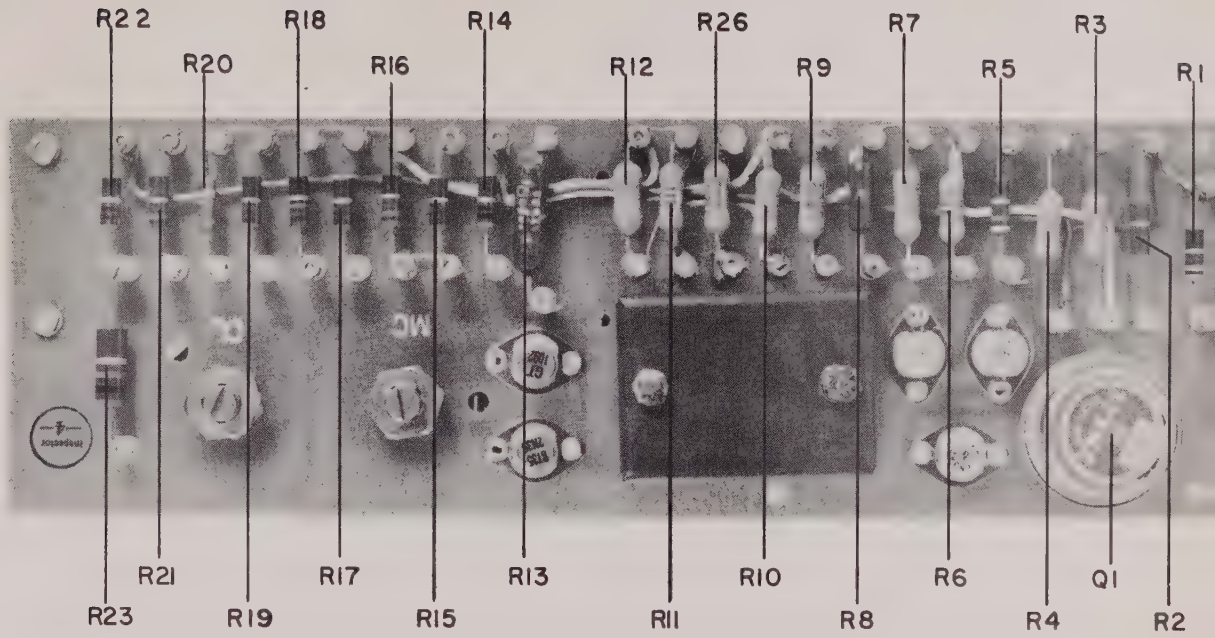
B301	- Fan		
C101	- 3300	MF	50 WV
C102	- 2000	MF	80 WV
C103	- 0.1	MF	500 WV
C104	- 0.22	MF	200 WV
C105	- 60	MF	250 WV
C106	- 350	MF	50 WV
C107 and C108	- 500	MF	12 WV
C109 and C110	- 100	MF	12 WV
C111 thru C114	- 0.22	MF	200 WV
C201	- 3300	MF	50 WV
C202	- 2000	MF	80 WV
C203	- 0.1	MF	500 WV
C204	- 0.22	MF	200 WV
C205	- 60	MF	250 WV
C206	- 350	MF	50 WV
C207 and C208	- 500	MF	12 WV
C209 and C210	- 100	MF	12 WV
C211 thru C214	- 0.22	MF	200 WV
CR101 and CR102	- Silicon Rectifier 6F20		
CR103 and CR104	- Silicon Rectifier PT-5		
CR105 thru CR112	- Germanium Rectifier 1N91		
CR201 and CR202	- Silicon Rectifier 6F20		
CR203 and CR204	- Silicon Rectifier PT-5		
CR205 thru CR212	- Germanium Rectifier 1N91		
F101	- 3 Amp. Fuse		
F102 and F103	- 1/4 Amp. Fuse		
F201	- 3 Amp. Fuse		
F202 and F203	- 1/4 Amp. Fuse		
F301	- 1/2 Amp. Fuse		
M101	- Meter, 0-1.5 A DC		
M102	- Meter, 0-50 V DC		
M201	- Meter, 0-1.5 A DC		
M202	- Meter, 0-50 V DC		
PL101	- Neon Pilot Light NE-51		
PL201	- Neon Pilot Light NE-51		

PARTS LIST - MODEL 2SC-32-1.5

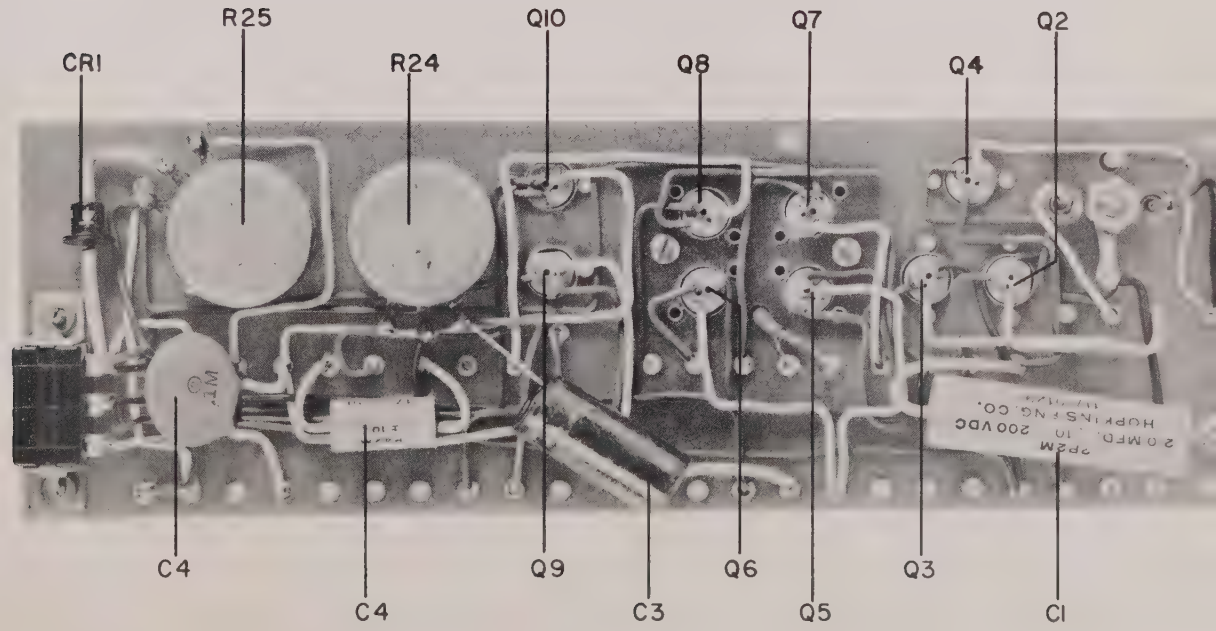
DRAWING S-2SC-32-1.5-02

PL101 and PL201	- Neon Pilot Light NE-51		
Q101 thru Q108	- Transistor 2N441-6		
Q109 and Q110	- Transistor 2N382 (Alternate 2N383)		
Q201 thru Q208	- Transistor 2N441-6		
Q209 and Q210	- Transistor 2N382 (Alternate 2N383)		
R101 thru R106	- 1.5	Ohm	3 watt WW
R107	- 10	K	10 turn Pot.
R108	- 500	Ohm	40 watt
R109	- 500	Ohm	20 watt
R110	- 1.5	Ohm	3 watt
R111	- 1	K	1/2 watt
R112	- 2	K	1 watt
R113	- 2.2	K	1 watt
R114	- 1	K	1/2 watt
R115	- 2.2	K	2 watt
R116 and R117	- 120	Ohm	1 watt
R118	- Omitted		
R119	- 47	Ohm	1/2 watt
R201 thru R206	- 1.5	Ohm	3 watt WW
R207	- 10	K	10 turn Pot.
R208	- 500	Ohm	40 watt
R209	- 500	Ohm	20 watt
R210	- 1.5	Ohm	3 watt
R211	- 1	K	1/2 watt
R212	- 2	K	1 watt
R213	- 2.2	K	1 watt
R214	- 1	K	1/2 watt
R215	- 2.2	K	2 watt
R216 and R217	- 120	Ohm	1 watt
R218	- Omitted		
R219	- 47	Ohm	1/2 watt
RL101 and RL102	- DPDT Relay		
RL201 and RL202	- DPDT Relay		
S101	- 3PDT Switch		
S102	- Thermoswitch N. O.		
S201	- 3PDT Switch		
S202	- Thermoswitch N. O.		
T101	- Kepco #100-1052		
T102	- Kepco #100-1039		
T201	- Kepco #100-1052		
T202	- Kepco #100-1039		
TB101 and TB201	- Jones #9-140-Y		

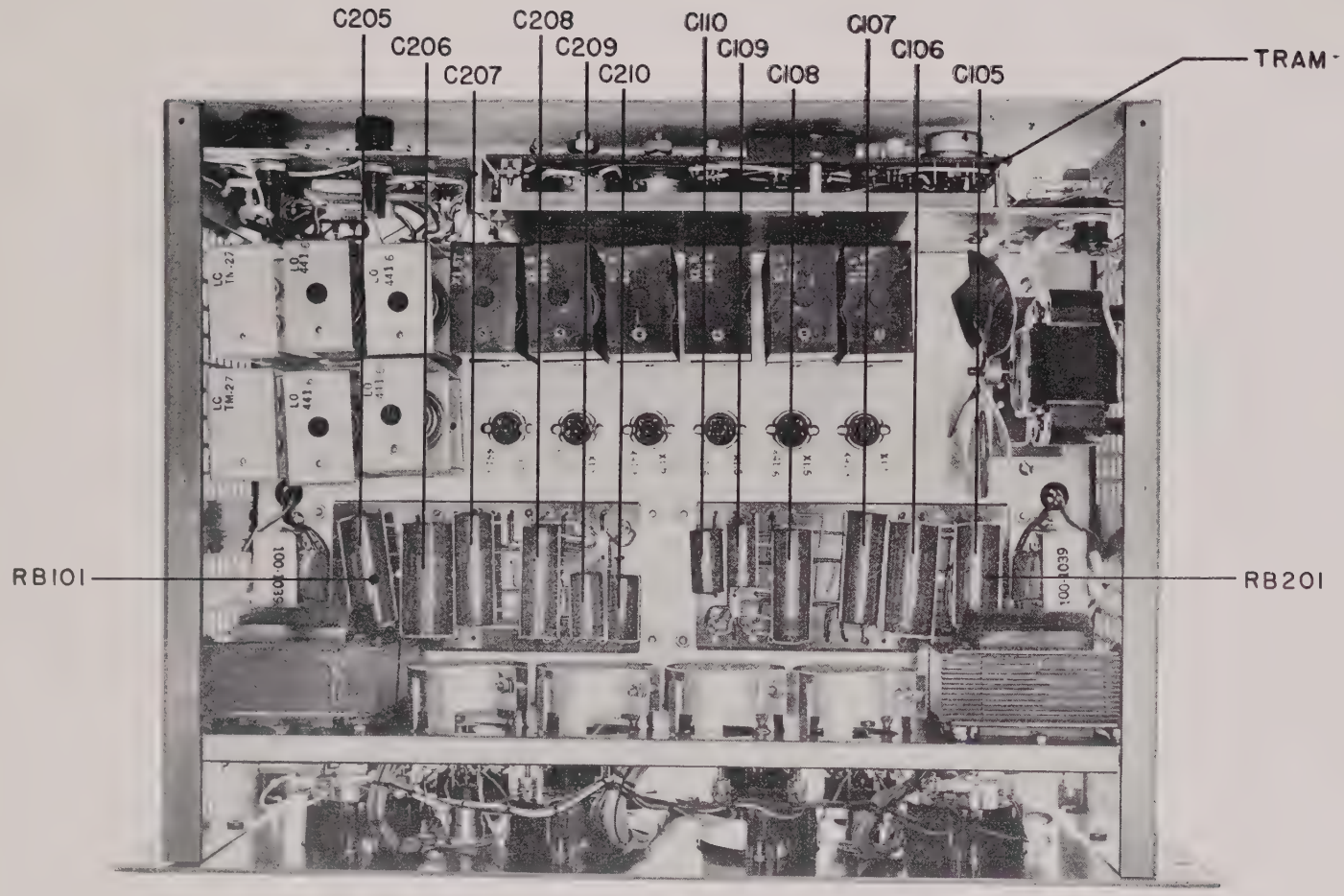
TOP



REAR

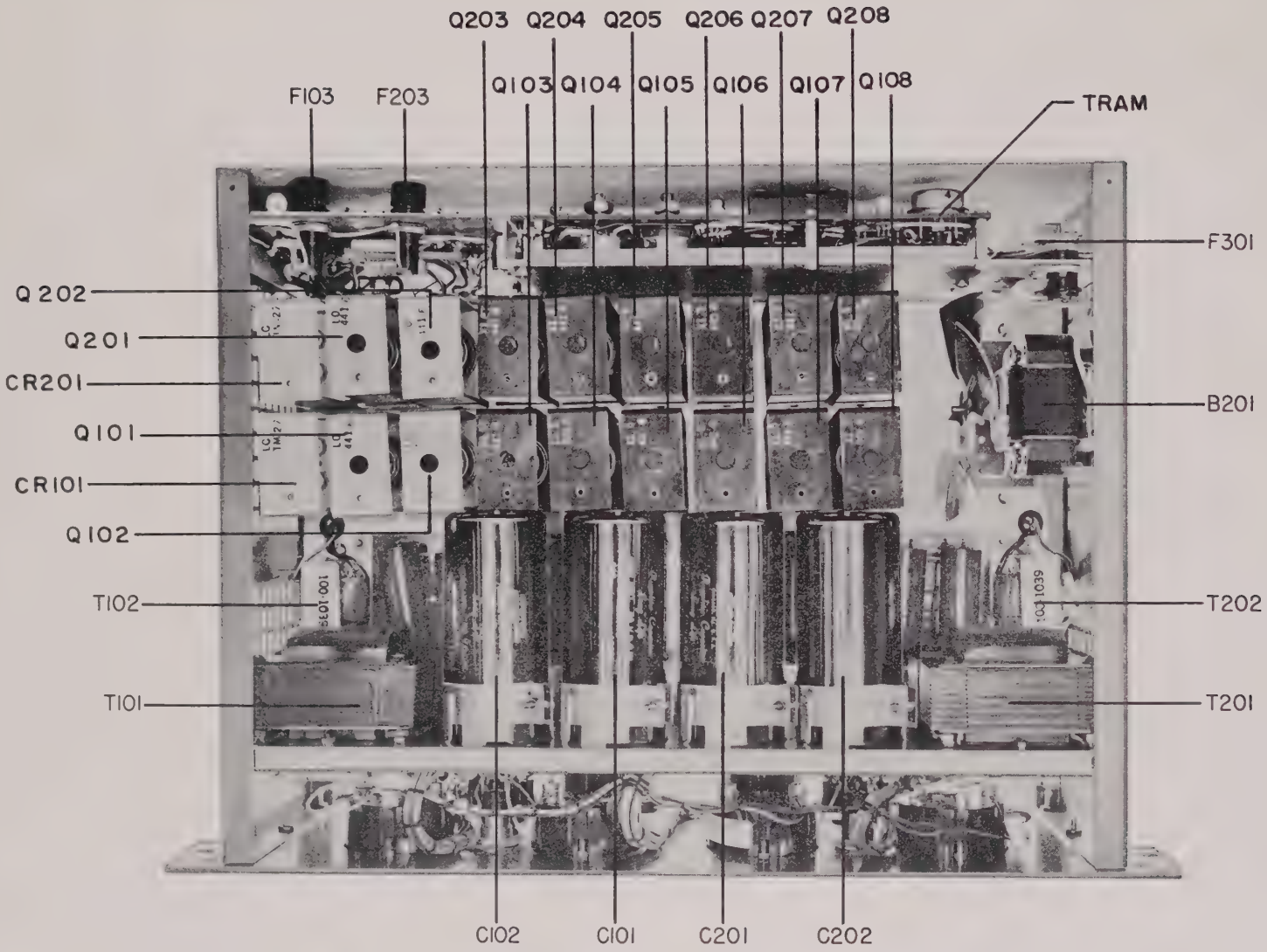


TRAM-4

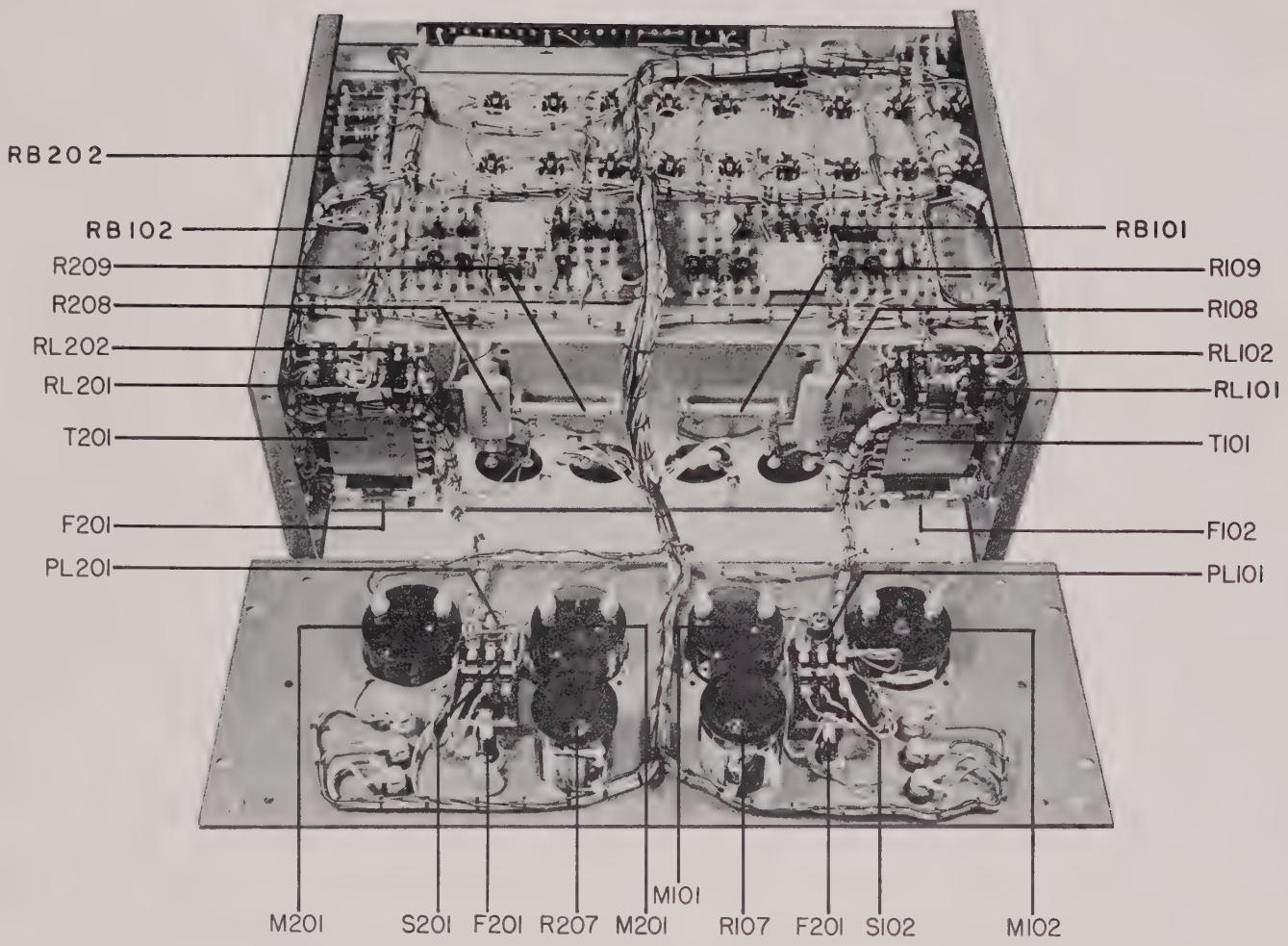


2SC-32-1.5 INTERIOR

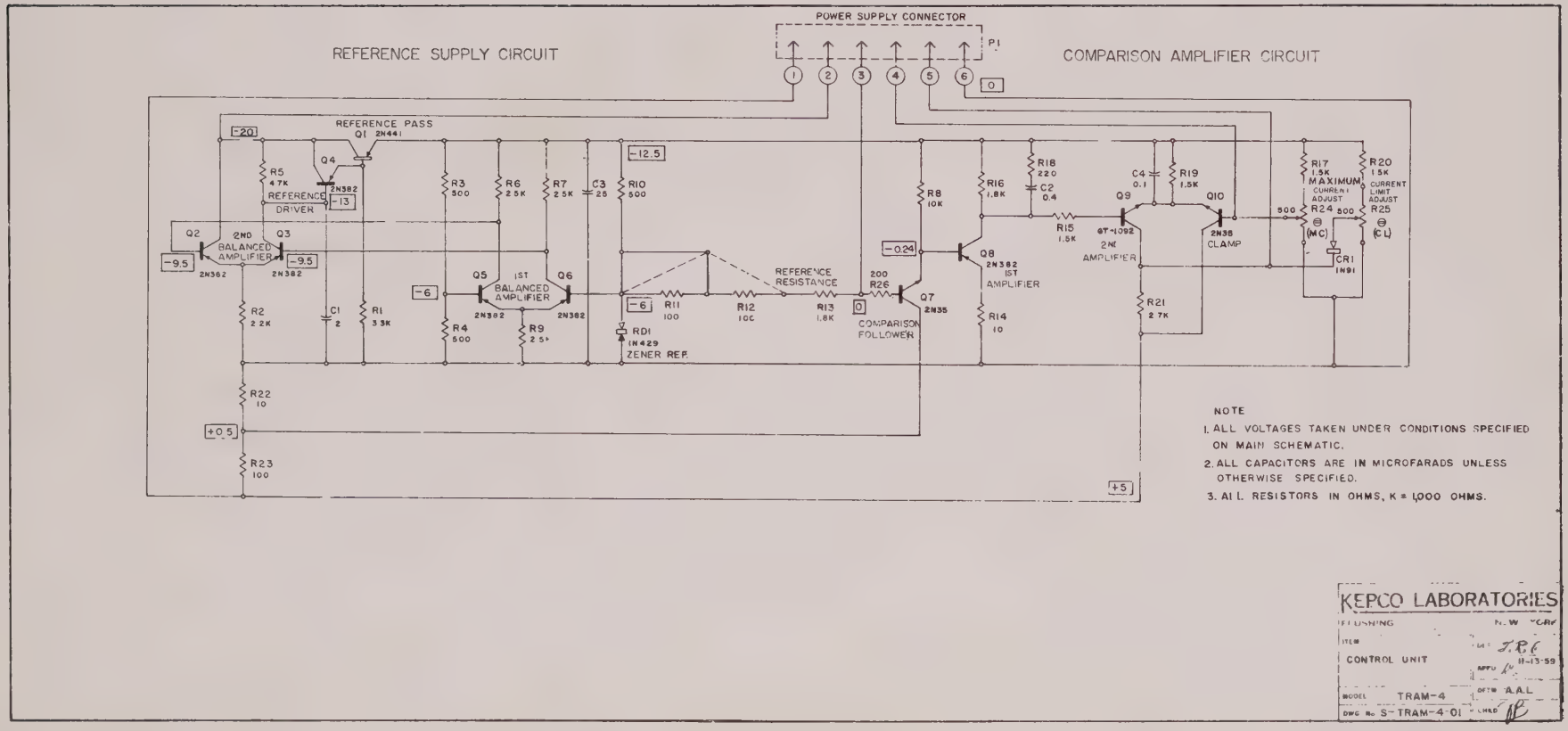
NOTE:
COMPONENTS C-101,102,201, 202 HAVE BEEN REMOVED FOR INTERIOR VIEW.


Q203
Q204
Q205
Q206
Q207
Q208
F103
F203
Q103
Q104
Q105
Q106
Q107
Q108
TRAM
F301
Q202
Q201
CR201
Q101
CR101
Q102
B201
T102
T202
T101
T201
C102
C101
C201
C202

2SC-32-1.5 TOP



2SC-32-1.5 FRONT

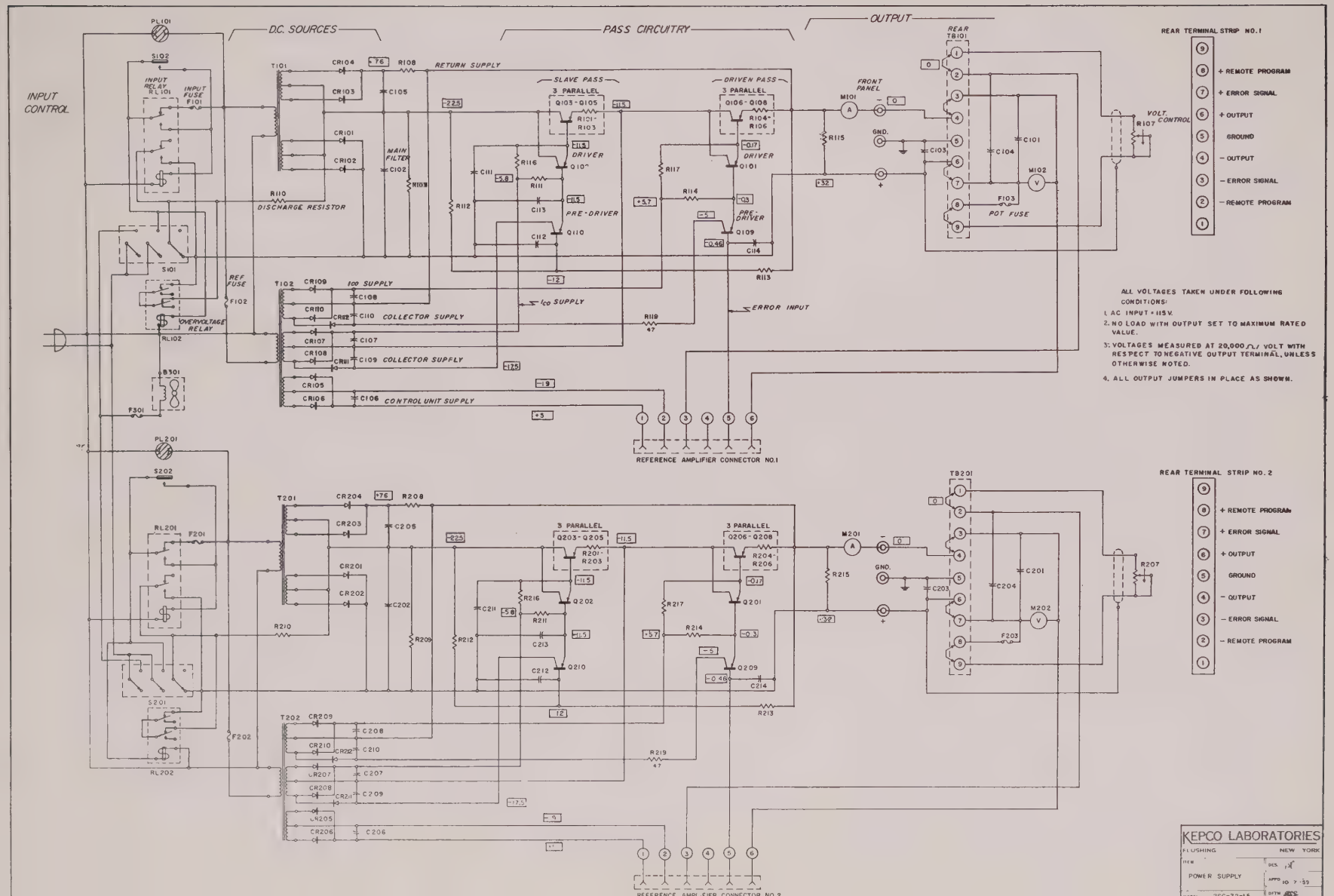


NOTE

1. ALL VOLTAGES TAKEN UNDER CONDITIONS SPECIFIED ON MAIN SCHEMATIC.
2. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
3. ALL RESISTORS IN OHMS, K = 1,000 OHMS.

KEPCO LABORATORIES

FINISHING	N.W. CORP
ITEM	DWG. J.R.C.
CONTROL UNIT	APPD. 11-13-59
MODEL TRAM-4	DFTM A.A.L.
DWG No. S-TRAM-4-01	CHKD



KEPCO LABORATORIES
FLUSHING NEW YORK
ITEM POWER SUPPLY
DES. JS
APPD. 10-7-59
DATE

Kepco inc.

KEPCO, INC. • 131-38 SANFORD AVENUE • FLUSHING 55, N. Y. • IN 1-7000